

Lost in Cloud

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Abstract— Cloud computing can reduce cost significantly because businesses can share computing resources. In recent years Small and Medium Businesses (SMB) have used Cloud effectively for cost saving and for sharing IT expenses. With the success of SMBs, many perceive that the larger enterprises ought to move into Cloud environment as well. Government agency's stove-piped environments are being considered as candidates for potential use of Cloud either as an enterprise entity or pockets of small communities.

Cloud Computing is the delivery of computing as a service rather than as a product, whereby shared resources, software, and information are provided to computers and other devices as a utility over a network. Underneath the offered services, there exists a modern infrastructure cost of which is often spread across its services or its investors.

As NASA is considered as an Enterprise class organization, like other enterprises, a shift has been occurring in perceiving its IT services as candidates for Cloud services. This paper discusses market trends in cloud computing from an enterprise angle and then addresses the topic of Cloud Computing for NASA in two possible forms. First, in the form of a public Cloud to support it as an enterprise, as well as to share it with the commercial and public at large. Second, as a private Cloud wherein the infrastructure is operated solely for NASA, whether managed internally or by a third-party and hosted internally or externally. The paper addresses the strengths and weaknesses of both paradigms of public and private Clouds, in both internally and externally operated settings. The content of the paper is from a NASA perspective but is applicable to any large enterprise with thousands of employees and contractors.

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1. INTRODUCTION

Cloud Computing is the new IT buzz around the block, bewildering many organizations on their decisions for their next steps in their IT solution portfolios. For many years

where an enterprise solution provider has claimed success and total gain over a market, it was by betting on the Small and Medium Businesses (SMB) IT needs. The SMB was an untapped market for years, and has been the dream of many investors. The SMB dilemma was simple; they could not afford large IT solutions. With the advent of public mail such as Gmail and Yahoo mail, the cloud computing extension was a logical step. To many SMB, the solution is free of charge for basic tools. The domino effect of SMB adoption on the rest of the market, however, was fast and effective and cloud computing is no exception as Figure 1 shows.

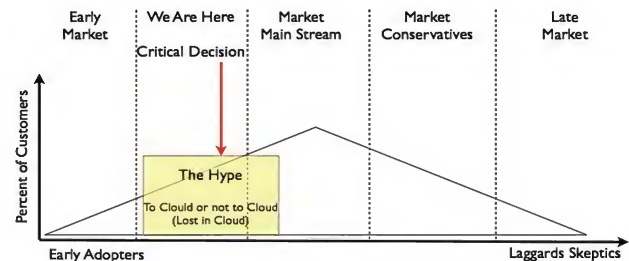


Figure 1- Cloud Computing Market Penetration

Cloud Computing offers specific services such as software, data access, and storage that do not require end-user knowledge of the physical location and configuration of the system that delivers the services. Thus reducing end-user maintenance cost. Cloud Computing is a term that meant to delineate a new business trend towards the service providers. Through an effective maturation process, a delivery model for general IT services based on Internet protocols has been made clear. It enables dynamic and seamless provisioning of hardware.

One of the end goals of Cloud Computing is to deliver applications over network. Cloud Computing provider's main technical achievements are scalability and resource sharing. At the foundation of Cloud Computing is the broader concept of infrastructure convergence. The evolution of data centers to Clouds are in a nutshell, connecting the data centers resources with modern software layers and modern operating systems with end goal to optimize the resource use over the internet.

2. OPTIONS IN CLOUD COMPUTING

As in many products, which go through much iteration in their developments and lifecycles, Cloud Computing is unique on its own as it is expressly tied to the end user

demand and supply. Notably the consumer space, at least perceived to be the whole spectrum and variety of small and large entity and businesses as a valid Cloud requirement drivers alike. For the simplicity of this paper we divided the Cloud categories into three topics, namely Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS), Cloud Infrastructure as a Service (IaaS). Their specific purposes are defined as below:

- Cloud Software as a Service (SaaS). The capability provided to the consumer is to use the provider's applications running on a Cloud infrastructure and accessible from various client devices through a thin client interface such as a Web browser (e.g., web-based email). The consumer does not manage or control the underlying Cloud infrastructure, network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- Cloud Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the Cloud infrastructure consumer-created applications using programming languages and tools supported by the provider (e.g., java, python, .Net). The consumer does not manage or control the underlying Cloud infrastructure, network, servers, operating systems, or storage, but the consumer has control over the deployed applications and possibly application hosting environment configurations.
- Cloud Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or does not control the underlying Cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly select networking components (e.g., firewalls, load balancers).

There will likely be many variations and new models will be emerging to solidify the maturity of the field. Many analysts will consider a potential split among the fields, mainly for better categorization and for segregated economy. Perhaps clarity on their purpose and future is important once these environments are considered to absorb the majority of the data in the world.

The main marketing scheme and customer feedback for Cloud computing is controversial to the point on who the actual end users are. Nonetheless, most market analyses are tainted by the spread of SMB type customers who benefit the most of the novelty of "pay what you use" paradigm. An enterprise analysis needs to be isolated and enterprise requirements should be analyzed differently from those of SMB. Typically the computing use of an enterprise is generally substantial larger.

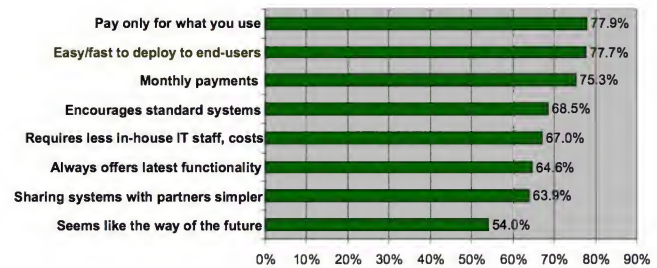


Figure 2- Cloud Benefit per category [3]

Before addressing NASA's enterprise needs for the Cloud computing, there needs to be a use-case development addressing the requirements that drove NASA being pockets of small communities. Each community would entail a computing environment tailored to its needs. However, it would be difficult to compare any of these communities to an SMB organization or an enterprise type. For example there is a substantial difference between a project schedule tool set up for a program and NASA Financial Systems. The latter is an enterprise scale environment. The former can reside in a cloud but the latter is risky.

A typical success in enterprise use of Cloud Computing could be established in the context of generic tools available on these computing resources. This benefit is immediate to the original investment as the software maintenance is minimized. Typically these online software environments would be open source frameworks, standard systems, or scripting languages where any requirement development or customization skills are commonly available in the market. The latter indeed reduces the risk of the enterprise of being locked on specific vendors leading to a data hostage scenario. In the government, or at least at NASA, any side tracking on specialized software use solely for common purposes is detrimental in both cost at the hourly rate and the process in its procurement (acquisition) often being a contract negotiated outside the scope of the general-purpose in-house contractors.

Nonetheless, these software vendors, challenged in losing their customers towards public Cloud, would launch their own vertical Cloud where the focus would be limited to their verticals and services, such as Salesforce.com. The latter are not private Cloud environments. NASA has indeed tested these public Cloud environments to establish a trade analysis of in-house or public environment. A break point cost analysis has found to in favor of enterprise Cloud given the amount of customization NASA requires, meeting the ever-changing nature of requirements. The cost of an in house infrastructure is negligible; for example when tier-1 and tier-2 services are added to the cost of the applications. The cost drops way below when the support teams and the infrastructure are within the same contract. Otherwise, a managed environment or tier-3 independent of its tier-3 will often result, as in an example of a ticket filed by an end-user, would find itself caught in a finger pointing dilemma

between the independent tier-2 and tier-3 at the expense of the customer and the frustrated end user.

On the other hand, the end-customer should be wary of locking itself into any public Cloud environment or vendor before having well understood the driving requirements. The customer should engage a trade analysis including imminent cost of pulling the data out of the Cloud or having a data migration path to a newer environment in an event of unexpected increase to the vendor cost in sustaining its operation beyond the original costing model. Nowadays, public environment cost models tend to be competitive even to the point of a free service mainly because they are competing to gain market share and to penetration new markets. However, this would be a temporary arrangement and soon public cloud environments will not be so cost effective.

3. GOVERNMENT NEEDS FOR CLOUD

The federal Cloud Computing initiative (FCCI) started as a result of the study of how the federal government can improve the performance and effectiveness of its IT infrastructure. The federal CIO identified Cloud Computing as a solution and in March 2009 formed the Cloud Computing Executive Steering Committee (CCESC). Later that year the White House Cloud-computing initiative was announced. Shortly after that Office of Management and Budget (OMB) issued Cloud guidance to the agencies stating agencies should evaluate the potential to adopt Cloud-computing solutions by analyzing computing alternatives for IT investments in FY 2012. The main goal of the FCCI is to make cloud-computing services accessible and easy to procure for Federal agencies. The most prominent actions taken so far towards development of Cloud include creation of a cloud computing definition by National Institute of Standards and Technology (NIST) and hosting a Cloud computing summit. The primary objectives of NIST are to promote Cloud standards and to provide guidance to government and industry in creation and management of the standards.

Cloud Computing offers various benefits to the government and allows the government to effectively use its IT investments. It brings efficiency, agility and innovation by partnering with the private sector. If a federal agency wants to launch a new innovative program, it can quickly do so by leveraging Cloud infrastructure without having to acquire significant hardware, lowering both time and cost barriers to deployment.

The government's need for Cloud Computing is not dissimilar from most of industry. In the Federal Cloud Computing Strategy [1] many needs are addressed with Cloud Computing benefits such as:

- (1) Data center consolidation
- (2) More efficient and secure management of software

- (3) Better utilization of excess server capacity
- (4) More agile services provided to consumers on demand
- (5) Increased integration of data and applications

Similar to some other federal agencies, NASA has additional specific scientific computing needs as cited in "NASA's Computing Strategy"(2)

- Flexible, scalable resources: Research scientists often start with minimal computing resources to prototype innovative ideas. They need the ability to start with small inexpensive systems – then if the prototype advances – be able to take advantage of full scale production level resources.
- Science Data Analysis: After collecting data through mission activities, scientists perform research for the principle investigators to extract useful information and turn that data into knowledge. Often, they will correlate large sets of data from other mission activities to create new insights. However, the totality of data that NASA collects is enormous and presents a challenge not only from a storage perspective, but also from the perspective of processing the data to integrate and mine it for results. Scientist must expend time and money to find effective ways to address their needs. Sometimes, they must resort to using capabilities that are not ideally suited for their specific problems. This can cause a reduction in quality, an increase in costs and/or risk, and a loss of time.
- Lower Procurement and Overhead Cost: Scientists often compete for research grants against non-federal entities. Federal scientists are at a disadvantage because there are several legal, policy and procedural challenges they must overcome that universities and/or commercial entities do not need to overcome. For example, the use of any Computing environment used by federal scientists must undergo Federal Information Security Management Act (FISMA) accreditation. This also drives the federal scientists to use particular technologies and controls like the Homeland Security Presidential Directive (HSPD) 12 for authentication. Without having a pre-configured system to address these, and other, challenges, federal scientists find that they are at a disadvantage due to the cost, time, and technical overhead involved.

4. NASA INVESTMENT IN CLOUD

NASA's Nebula Cloud Computing initiative was started three years ago. It is the first open-source Cloud-computing platform built by the federal government to provision infrastructure including high-performance computing and storage. In early 2010, NASA launched IaaS with the White House as the first customer. Soon after that Nebula became the basis of OpenStack, an open-source initiative aimed at driving Cloud-computing standards. The contribution to

OpenStack aligns with the NASA's strategic goals. It is going to help the agency to promote industry, academic and international partners.

Nebula's private Cloud capability is not just for providing scalable web hosting platform but it is targeted at science-class workloads. It almost exclusively uses open source components. The source code for IaaS produced by NASA is released as open source.

Today, scientists and engineers at NASA are rapidly moving towards utilizing Cloud computing in various agency programs. Cloud computing has become a critical tool for NASA future success since it can be used to address scalability problems in processing and storing large datasets, which continue to grow within the Agency.

5. INDUSTRY TRENDS AND USE

Demand for Cloud Computing is growing as it enables on-demand information technology services and products. The explosive growth of Cloud Computing is driven by and contributes to utility computing, on-demand computing, autonomic computing, and Green IT. Although the concept of Cloud computing has been around for a while in the industry, in recent years a number of technologies have been developed to realize the concept and make Cloud Computing more accessible. Various companies including large companies like Google, Microsoft, and Amazon, and many startups, are leading the most new exciting developments in cloud technologies today. Although most of the IT industry is ready to adopt these exciting new technologies, there are still many challenges to Cloud Computing reaching its full potential. One of the biggest challenges today is maintaining privacy and security of the data in the Cloud. We are confident that a combination of innovative solutions and changes in regulations will soon address the security and privacy concerns.

A lot of companies are, therefore, utilizing a hybrid model that enables a composition of private and public Cloud. A 'public Cloud' is designed for a market, not a single enterprise. It is open to a largely unrestricted universe of potential users. A 'private Cloud', on the other hand, is designed for, and access restricted to, a single enterprise.

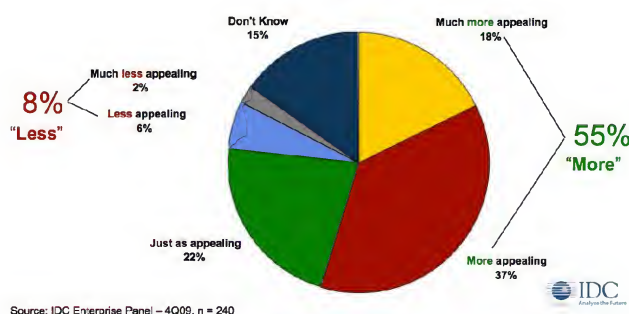


Figure 3- Preference of Private Cloud vs. Public Cloud
(Source IDC)

Figure 3 is the result of IDC's Cloud services survey conducted in 2010 to understand the appeal of Private Cloud versus Public Cloud. The preference of Private Cloud shown is perhaps a demand driven by the market mainstream customers with the requirements needed to make the decision to move forward or increase their use.

Figure 4 shows the break down of anticipated demand by application between the public and private clouds. The demand for private clouds is anticipated to be slightly higher in every application category.

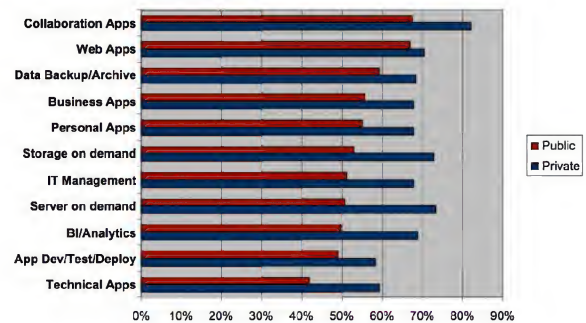


Figure 4- Anticipated Growth of Private compared to Public Cloud [3].

Enterprise attitudes towards public Cloud services have been ambivalent at best. In a recent enterprise survey, a majority of the respondents rated the following top three 'benefits' of public Cloud services:

- Pay only for what you use (77.9%)
- Easy/fast to deploy to end-users (77.7%)
- Monthly payments (75.3%)

However, the same enterprise customers overwhelmingly rated the following top three 'challenges/issues' with the same public Cloud services:

- Security (87.5%)
- Availability (83.3%)
- Performance (82.9%)

As a result, worldwide spending on public Cloud services is expected to grow to only about \$45 billion, or a little more than 10% of the total IT spending of \$416 billion by 2013.

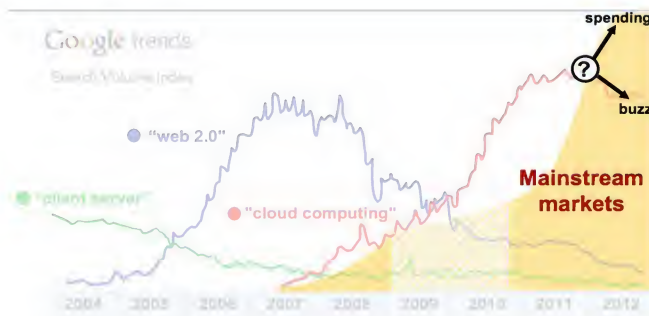


Figure 5- End of Cloud Computing Era [3]

While every beginning has an end, one cannot avoid wondering what the end in Cloud Computing would be given the investments made. The anticipation of the end of client server has been forecasted back in 2001, even NASA grid computing effort and R&D has anticipated such an end to the client server environments. In the same fashion, the end of Cloud Computing can be forecasted to the extent where the mainstreams of enterprise markets and users demands meet the supply of what Cloud Computing can offer. Moving enterprise data to the Cloud is a daunting task, but if ever to happen, many questions will need to be answered beforehand. The only condition where Cloud could guarantee its future as effective solution is to address the SMB market for few more years before marketing the enterprise as an extension to SMB.

We believe a 'private Cloud' that is designed for, and access restricted to, a single enterprise, is the solution for the enterprise market. A private Cloud provides all of the benefits of using Cloud technologies while addressing the challenges/issues identified above with public Clouds.

6. CLOUD AS AN ASSET OR LIABILITY

Every day a company or two discloses data breach to their customers and end-users. Data loss and data leakages have become prominent concerns for businesses and government institutions. A study shows that most of the data breaches are intentional. More often than none they are result of employee behavior and have very little to do with a specific IT solution. Data breach of sensitive intellectual property and private information can increase liabilities and litigations. Considering the trend of cyberspace security challenges forecasted by the US congress analysts, government agencies are truly at a higher risk than others.

In order to mitigate the risk, most government agencies and NIST vouch for a security certification. Although most public Cloud providers are willing to certify, not a single provider is willing to sign off on the liability of data loss and data leakage. Moving data assets from existing datacenters to public Cloud with out an indemnification clause in the contracts will be a huge liability risk for NASA. However, such risks should not deter NASA from using Cloud computing. NASA can still take full advantage of Cloud but minimize the risk through the use of Private

Cloud. In the case of private Cloud environment at NASA, the offering will be made available behind a firewall and maintained according to the NASA standards and policies.

The agility in data archiving is another key benefit of private Cloud. As most would agree, NASA is a data-collecting agency, thus NASA is as good as its data. Therefore, it is extremely important for NASA to protect and preserve its data assets.

7. CONCLUSION

We believe a 'Private Cloud' that is designed for, and access restricted to, a single enterprise, is the primary solution for the government just as in the case of the enterprise market. A Private Cloud provides all of the benefits of using Cloud computing technologies while addressing the challenges/issues identified above with Public Cloud. However, as a shared internal resource, the IT organization has to act as the "vendor" of the private Cloud to its consumers. Private Cloud solution will be more expensive compared to the Public Cloud but it is well worth the security and data breach prevention benefits it provides.

As Figure 1 in the beginning of the paper shows, Cloud Computing has not yet hit the market mainstream and NASA should not play an early adopter role. However, NASA can benefit tremendously from leveraging cloud technologies in form of an in house private Cloud, at least from the stand point of IT consolidation.

8. REFERENCES

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9. BIOGRAPHIES

David A. Maluf, Ph.D. received his Ph.D. from McGill University in 1995 and his postdoctoral from Stanford University. He has been involved in Intelligent Information Integration and databases since. David was also Director of Software Development at Incyte. Before NASA, David founded and operated Science Gate as CTO. The company was successfully acquired. At NASA, David was the Project Manager for Knowledge Engineering under the Engineering for Complex Systems program. David was the CIO for the program. In conjunction with the FAA, David has been leading, from its inception, the development and operation of very large government information grid projects, connecting US government centers nationwide. Currently David is the Technical Area Lead for The Collaborative Assistant Systems in the Intelligent Division Systems at Ames. He is the inventor of many NASA patents, including Netmark tool suites, which were commercialized leading to products such as NX and PMT

Sandeep D. Shetye is presently serving as Chief Information Architect in the NASA Office of the Chief Information Officer, leading Agency Information Architecture effort. He is responsible for developing, implementing, maintaining and advocating the agency's Information Architecture. He was also involved in the initial development of NASA's Nebula Cloud infrastructure. Sandeep brings over 18 years experience in IT strategic planning, architecture development, and IT solutions including over 4 years working at NASA. He is experienced in guiding cross-functional teams through design and launch of leading-edge technology and business solutions. Prior to joining NASA, he worked as an architect for companies including Intel, Cisco Systems, Sony, and a couple of successful startups. Sandeep holds a bachelor's degree in physics and a master's degree in computer science.

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Ian Sturken has over 20 years experience leading teams in the development of software systems. He has worked at several companies including Tandem Computers and Compaq producing software for fault tolerant systems management. Since joining NASA he has performed in various capacities including working on information organization using semantic technologies and building system solutions for mission support. Currently he is one of the leads defining agency application architecture as well as working to define an agency strategy for web services. Ian holds BS degrees in Computer & Information Sciences and Economics from University of California, Santa Cruz.